Core Formation on EPB, Moon, Mars, Earth & Venus:

Rhapsody on a Theme by ~~Paganini~~ Ringwood

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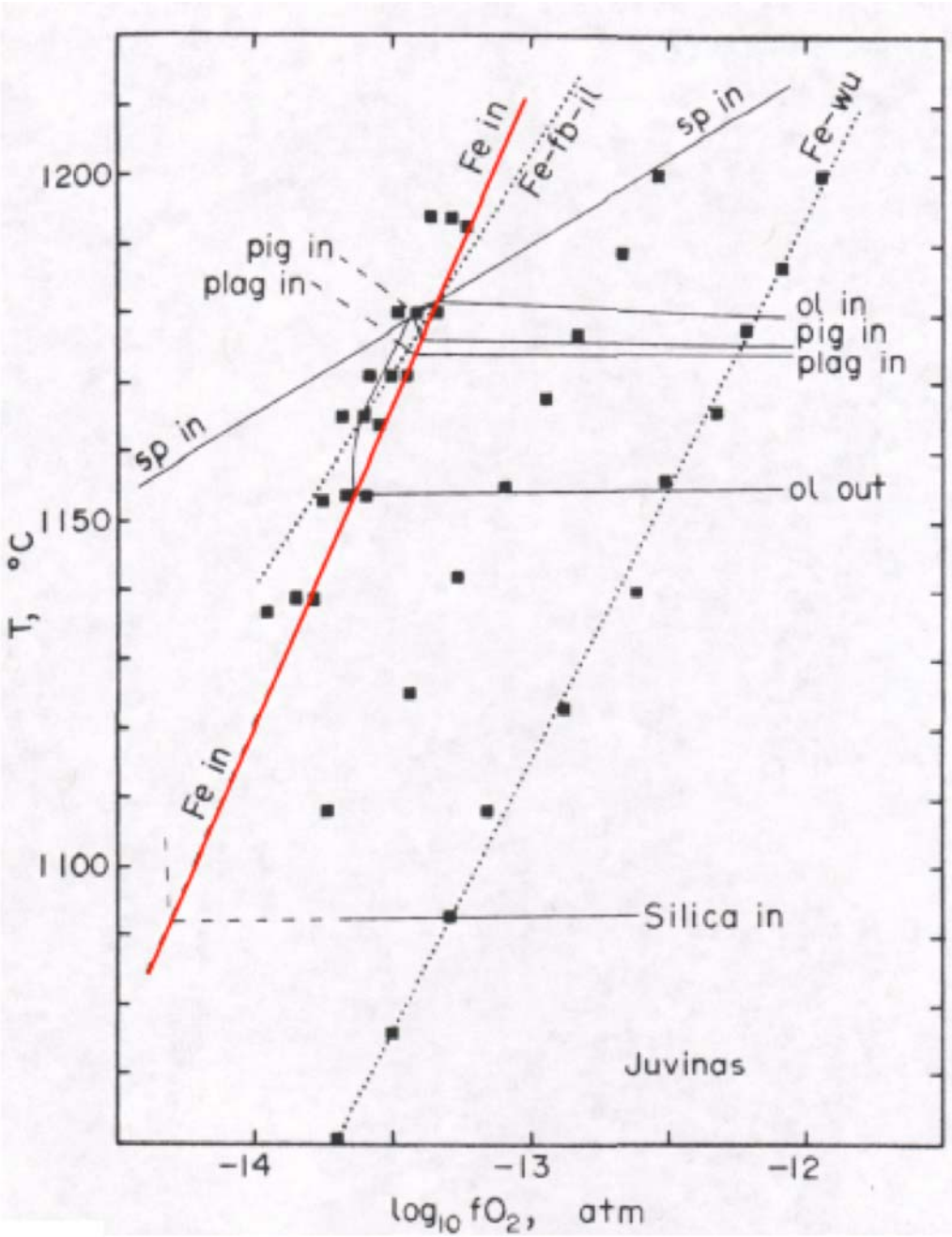
What Should the FeO Content of Planetary Basalts Be?

- Eucrites contain ~18 wt.% FeO
- Experiments of Stolper (1977) constrain the metal-silicate equilibria for one body — the EPB
  - Look for multiple saturation of melt, olivine, pyroxene, metal ± alumino-silicate
  - For eucrites this occurs at ~ IW-1
- This is about the fo_2 of an ordinary chondrite



Stolper, 1977

What About the Moon?

- Mare basalts also contain ~18 wt.% FeO

- Experiments of Walker et al. (1977) showed that mare basalts are nearly metal saturated
  - Experiments in pure Fe capsules neither gained nor lost FeO

- Implies that mare basalts are also formed at ~IW-1

What About Mars?

- Basaltic shergottites also have about ~18 wt.% FeO
- Primitive shergottites from the depleted shergottite mantle have fo_2's in the vicinity of IW
- Because Mars has a core, the inference is that the martian mantle is also at or near IW-1

What About the Earth?

- MORB & Arc magmas typically have ~8-10 wt.% FeO*
- OIB have slightly higher FeO contents, ~10-12 wt.%
- Fertile mantle xenoliths (spinel lherzolites) typically contain ~8 wt.% FeO
- The Earth appears to have lower FeO than the EPB, the Moon, and Mars

What about Venus?

- Only analyses of venusian basalts come from the short-lived Venera missions
- Within the uncertainties of the analyses, venusian basalts appear very "Earthlike"
  - ~10 wt.% FeO
- There is an apparent correlation between FeO content and planetary size

Comparative Planetology of FeO

	Eucrite Juvinas	Mare Basalt 15555	Shergottite Y980459	MORB Average	Venera 13	Venera 14
SiO_2	49.3	44.6	48.7	49.9	45.1	48.7
TiO_2	0.64	2.1	0.54	1.51	1.6	1.25
Al_2O_3	13.0	8.7	5.3	17.2	15.8	17.9
FeO*	18.8	22.5	17.5	8.7	9.3	8.8
MnO	0.56	0.29	0.52	0.17	0.2	0.16
MgO	7.3	11.4	6.4	7.28	11.4	8.1
CaO	10.4	9.4	19.6	11.9	7.1	10.3
Na_2O	0.47	0.27	0.48	2.8	—	—
Sum	100.8	99.2	99.0	99.5	90.5	95.2

Why?

Larger bodies are more reduced & have intrinsically less FeO?

- Wänke heterogeneous accretion model
- Why are the Earth and Moon different?
- Same oxygen & chromium isotopes but different FeO?
- Earth-Moon comparisons suggest that Earth's FeO content is not inherited

Why? Con't

Disproportionation of FeO into Fe & Fe_2O_3?

- Frost et al. experiments in perovskite field
  - Have these been reproduced?
- Does not explain high mantle siderophile element abundances
- Can fine-grained metal be separated from silicate matrix?

Why? Con't

FeO has entered the cores of Earth & Venus at high (P,T)?

- Ringwood hypothesis based on almost no data
- Stolper experiments not yet published?
- At the time SNC's were not known to be from Mars & the Venera Missions were not yet launched
- Still has the fewest objections?

Implications for the Earth's (and Venus'?) Core

- Need to reduce FeO from ~25 wt.% (EPB-like) to 8 wt.% (Earth-like) by removing 17 wt.% FeO to the core
- This means 3.8 wt.% O removed from mantle to the core
- Corresponds to 4.1 wt.% O in core (4.5% if there is no O in the inner core)
- A combination of O and S might explain the density deficit of the outer core (~9-10 wt.%)

Summary

- FeO contents of planetary mantles seem to be dependent on planet size
- Need mechanism to accomplish this
- FeO into the Earth/Venus cores? Negative ΔV can cause an unfavorable reaction to occur at high pressure